Chapter H4: Economic Value of I&E Losses Based on Benefits Transfer Techniques

This chapter presents an analysis using benefits transfer techniques of the economic losses associated with I&E at the J.R. Whiting facility without the currently installed impingement deterrent net using I&E data for 1978 and 1979 only (baseline). Section H4-1 provides an overview of the valuation approach, Section H4-2 discusses the value of recreational fishery losses, Section H4-3 discusses commercial fishery values, Section H4-4 discusses the value of forage species losses, Section H4-5 discusses nonuse values, and Section H4-6 summarizes the benefits transfer results. Chapter H5 discusses the results of an alternative valuation approach (the Habitat-based Replacement Cost methodology) and Chapter H6 discusses potential benefits of reductions in I&E.

CHAPTER CONTENTS

H4-1 Overview of Valuation Approach

Fish losses from I&E at J.R. Whiting affect commercial and recreational fisheries, as well as forage species that contribute to the biomass of commercial and recreational species. EPA evaluated all of these species groups to capture the total economic impact of I&E at J.R. Whiting.

Commercial fishery impacts are based on commodity prices for the individual species. Recreational fishery impacts are based on benefits transfer methods, applying the results from nonmarket valuation studies. The economic impact of forage species losses is determined by estimating the replacement cost of these fish if they were to be restocked with hatchery fish (ignoring several costs and issues associated with restocking), and by considering the foregone biomass production of forage fish resulting from I&E losses and the consequential foregone production of commercial and recreational species that prey on the forage species. All of these methods are explained in further detail in the Chapter A9 in Part A of this document.

Many of the I&E-impacted fish species at J.R. Whiting are harvested both recreationally and commercially. Table H4-1 presents the percentage impacts of the I&E losses occurring to the commercial and recreational fisheries. To avoid double-counting the economic impacts of I&E occurring to species that are both commercially and recreationally fished but for which locally and applicable catch data were not available, EPA assumed that 50 percent of the estimated catch of I&E-impacted fish are assigned to a loss in commercial landings, and the remaining 50 percent of the estimated total number of losses due to I&E are assigned to the recreational landings.

Table H4-1: Percentages of Total I&E Impacts at J.R. Whiting Occurring to Commercial and Recreational Fisheries

Fish Species	Percent Impacts to Recreational Fishery	Percent Impacts to Commercial Fishery
Bullhead spp.	0	100
Channel catfish	50	50
Common carp	0	100
Crappie spp.	100	0
Gizzard shad	0	100
Sucker spp.	0	100
Sunfish spp.	100	0
Walleye	100	0
White bass	50	50
White perch	100	0
Yellow perch	100	0

Wed Jan 09 14:09:50 MST 2002 ; Table A: Percentages of total impacts occurring to the commercial and recreational fisheries of selected species; Plant: jr.whiting.78.79 ; Pathname: P:/Intake/Great_Lakes/GL_Science/scodes/jr.whiting/tables.output.78.79/TableA.Perc.of total.impacts.jr.whiting.78.79.csv

As discussed in Chapters A5 and A9 of Part A of this document, the yield estimates presented in Chapter H3 are expressed as total pounds for both the commercial and recreational catch combined. For the economic valuation discussed in this chapter, total yield was partitioned between commercial and recreational fisheries based on the landings in each fishery (presented in Table H4-1). Because the economic evaluation of recreational yield is based on numbers of fish rather than pounds, foregone recreational yield was converted to numbers of fish. This conversion was based on the average weight of harvestable fish of each species. Table H4-2 shows these conversions for the impingement data presented in Section H3-4.1 of Chapter H3 and Table H4-3 displays these data for the entrainment estimates given in Section H3-4.2. Note that the numbers of foregone recreational fish harvested are typically lower than the numbers of age 1 equivalent losses, since the age of harvest of most fish is greater than age 1.

Table H4-2: Summary of Mean Annual Impingement of Fishery Species at J.R. Whiting (without impingement deterrent net)

Species	Impingement Count (#)	Age 1 Equivalents (#)	Total Catch (#)	Total Yield (lb)	Commercial Catch (#)	Commercial Yield (lb)	Recreational Catch (#)	Recreational Yield (lb)
Bullhead spp.	1,721	2,001	96	30	96	30	0	0
Channel catfish	2,300	2,965	112	93	56	46	56	46
Common carp	55,321	60,640	4,482	29,303	4,482	29,303	0	0
Crappie spp.	568	687	10	6	0	0	10	6
Freshwater drum	33,776	38,970	2,265	2,070	2,265	2,070	0	0
Gizzard shad	11,715,924	20,459,337	2,608,142	807,576	2,608,142	807,576	0	0
Sucker spp.	1,040	1,246	31	15	31	15	0	0
Sunfish spp.	1,032	1,720	10	1	0	0	10	1
Walleye	4,084	4,699	381	825	0	0	381	825
White bass	36,498	48,937	5,872	4,136	2,936	2,068	2,936	2,068
White perch	0	0	0	0	0	0	0	0
Yellow perch	88,434	104,225	1,953	246	0	0	1,953	246
Total	11,940,698	20,725,427	2,623,353	844,300	2,618,007	841,109	5,346	3,191

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Table H4-3: Summary of Mean Annual Entrainment of Fishery Species at J.R. Whiting (without impingement deterrent net)

Species	Entrainment Count (#)	Age 1 Equivalents (#)	Total Catch (#)	Total Yield (lb)	Commercial Catch (#)	Commercial Yield (lb)	Recreational Catch (#)	Recreational Yield (lb)
Channel catfish	28,918	143	5	4	3	2	3	1
Common carp	7,372,177	36,496	2,697	17,636	2,697	17,636	0	0
Crappie spp	132,964	5,391	79	45	0	0	79	23
Freshwater drum	32,762,696	29,768	1,731	1,581	1,731	1,581	0	0
Gizzard shad	569,558,422	1,221,061	155,660	48,198	155,660	48,198	0	0
Sucker spp	268,228	3,853	95	48	95	48	0	0
Sunfish spp	1,040,904	350,828	2,053	127	0	0	2,053	64
Walleye	0	0	0	0	0	0	0	1
White bass	5,679,922	28,118	3,374	2,377	1,687	1,188	1,687	594
White perch	0	0	0	0	0	0	0	1
Yellow perch	2,788,745	12,360	232	29	0	0	232	15
Total	619,632,976	1,688,020	165,927	70,045	161,873	68,654	4,054	699

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H4-2 Value of Baseline Recreational Fishery Losses at J.R. Whiting Facility

H4-2.1 Economic Values for Recreational Losses Based on Literature

There is a large literature that provides willingness-to-pay values for increases in recreational catch rates. These increases in value are benefits to the anglers, and are often referred to by economists as a "consumer surplus" per additional fish caught.

When using values from the existing literature as proxies for the value of a trip or fish at a site not studied, it is important to select values for similar areas and species. Table H4-4 gives a summary of several studies that are closest to the Great Lakes fishery in geographic area and relevant species.

Table H4-4: Selected Valuation Studies for Estimating Changes in Catch Rates

Authors	Study Location and Year	Item Valued	Value Estimate ($2000)	
Boyle et al. (1998)	National, by state, 1996	Catch rate increase of 1 fish per trip	Bass (low/high)	$1.58 - $5.32
Sorg et al. (1985)	Idaho, 1982	Catch rate increase of 1 fish per trip	Warmwater fish	$5.02
Milliman et al. (1992)	Green Bay	Catch rate increase of 1 fish per trip	Yellow perch	$0.31
Charbonneau and Hay (1978)	National, 1975	Catch rate increase of 1 fish per trip	Walleye Catfish Panfish	$7.92 $2.64 $1.00

[a] Value was reported as "two month value per angler for a half fish catch increase per trip." From 1996 National Survey of Fishing, Hunting and Wildlife-Associated Recreation (U.S. DOI, 1997), the average saltwater angler takes 1.5 trips in a 2 month period. Therefore, to convert to a "1 fish per trip" value EPA divided the 2 month value by 1.5 trips and then multiplied it by 2, assuming the value of a fish was linear.

Boyle et al. (1998) used the 1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation to estimate the marginal economic value of an additional bass, trout, and walleye per trip.

Sorg et al. (1985) used travel cost and contingent valuation methods to estimated the value of recreational fishing at 51 sites in Idaho. Several of the species valued in Sorg et al. are also found in the Great Lakes fishery.

Milliman et al. (1992) used a logit model and the responses, creel data, and the responses to a contingent valuation dichotomous choice survey question the study estimated the value of recreational fishing for Yellow Perch in Green Bay, Michigan.

Charbonneau and Hay (1978) used travel cost and contingent valuation methods to estimate the consumer surplus for a season of the respondent's favorite wildlife-related activity. These consumer surplus values were then converted to a one fish increase per trip.

EPA estimated the economic value of I&E impacts to recreational fisheries using the I&E estimates presented in Tables H4-2 and H4-3 and the economic values in Table H4-4. Since none of the studies discussed in the previous section consider the Great Lakes fishery directly, EPA used these estimates to create a range of possible consumer surplus values for the recreational fish landings gained by reducing impingement and entrainment at J.R. Whiting. To estimate a unit value for recreational landings, EPA established a lower and upper value for the recreational species, based on values reported in studies in Table H4-4.

H4-2.2 Baseline Economic Losses from Recreational Fishing

EPA applied a 50/50 recreational and commercial split to obtain the losses to the recreational fishery where a fish is both commercially or recreationally harvested. If not commercially harvested, recreational losses were assumed to be 100 percent of losses due to I&E, and vice versa. Results are displayed in Tables H4-5 and H4-6, for impingement and entrainment, respectively. The total losses to the recreational fisheries are estimated to range from $7,300 to $20,900 for impingement per year, and from $3,500 to $11,700 annually for entrainment.

Table H4-5: Baseline Annual Recreational Impingement Losses at the J.R. Whiting Facility and Associated Economic Values

Species	Loss to Recreational Catch from Impingement (# of fish)	Recreational Value/Fish		Loss in Recreational Value from Impingement	
		Low	High	Low	High
Channel catfish	56	$2.64	$5.02	$147	$280
Crappie spp.	10	$1.00	$5.02	$10	$51
Sunfish spp.	10	$0.31	$1.00	$3	$10
Walleye	381	$5.02	$7.92	$1,912	$3,016
White bass	2,936	$1.58	$5.32	$4,639	$15,619
White perch	0	$0.31	$1.00	$0	$0
Yellow perch	1,953	$0.31	$1.00	$606	$1,953
Total	5,346			$7,316	$20,929

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Table H4-6: Baseline Annual Recreational Entrainment Losses at the J.R. Whiting Facility and Associated Economic Values

Species	Loss to Recreational Catch from Entrainment (# of fish)	Recreational Value/Fish		Loss in Recreational Value from Entrainment	
		Low	High	Low	High
Channel catfish	3	$2.64	$5.02	$7	$14
Crappie spp.	79	$1.00	$5.02	$79	$399
Sunfish spp.	2,053	$0.31	$1.00	$637	$2,053
Walleye	0	$5.02	$7.92	$0	$0
White bass	1,687	$1.58	$5.32	$2,665	$8,975
Yellow perch	232	$0.31	$1.00	$72	$232
Total	4,054			$3,460	$11,672

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H4-3 Baseline Economic Losses from Commercial Fishing

I&E losses to commercial catch (pounds) are presented in Tables H4-2 (for impingement) and H4-3 (for entrainment) based on the recreational and commercial splits in Table H4-1. EPA estimates of the economic value of these losses are displayed in Tables H4-7 and H4-8. Values for commercial fishing are relatively straightforward because commercially caught fish are a commodity with a market price. The market value of foregone landings to commercial fisheries is $128,300 for impingement per year, and $11,600 annually for entrainment.

Tables H4-7 and H4-8 express commercial impacts based on dockside market prices only. However, to determine the total economic impact from changes to the commercial fishery, EPA also determined the losses experienced by producers wholesalers, retailers and consumers. The total social benefits (economic surplus) are greater than the increase in dockside landings, because the increased landings by commercial fishermen contribute to economic surplus in each of a multi-tiered set of markets for commercial fish. The total economic surplus impact thus is valued by examining the multi-tiered markets through which the landed fish are sold, according to the methods and data detailed in Chapter A9.

The first step of the analysis involves a fishery-based assessment of I&E-related changes in commercial landings (pounds of commercial species as sold dockside by commercial harvesters). The results of this dockside landings value step are described above. The next steps then entail tracking the anticipated additional economic surplus generated as the landed fish pass from dockside transactions to other wholesalers, retailers and, ultimately, consumers. The resulting total economic surplus measures include producer surplus to the watermen who harvest the fish, as well as the rents and consumer surplus that accrue to buyers and sellers in the sequence of market transactions that apply in the commercial fishery context.

To estimate producer surplus from the landings values, EPA relied on empirical results from various researchers that can be used to infer producer surplus for watermen based on gross revenues (landings times wholesale price). The economic literature (Huppert, 1990; Rettig and McCarl, 1985) suggests that producer surplus values for commercial fishing ranges from 50 to 90 percent of the market value. In assessments of Great Lakes fisheries, an estimate of approximately 40% has been derived as the relationship between gross revenues and the surplus of commercial fishermen (Cleland and Bishop, 1984, Bishop, personal communication, 2002). For the purposes of this study, EPA believes producer surplus to watermen is probably in the range of 40% to 70% of dockside landings values.

Producer surplus is one portion of the total economic surplus impacted by increased commercial stocks — the total benefits are comprised of the economic surplus to producers, wholesalers, processors, retailers, and consumers. Primary empirical research deriving "multi-market" welfare measures for commercial fisheries have estimated that surplus accruing to commercial anglers amount to approximately 22% of the total surplus accruing to watermen, retailers and consumers combined (Norton et al., 1983; Holt and Bishop, 2002). Thus, total economic surplus across the relevant commercial fisheries multi-tiered markets can be estimated as approximately 4.5 times greater than producer surplus alone (given that producer surplus is roughly 22% of the total surplus generated). This relationship is applied in the case studies to estimate total surplus from the projected changes in commercial landings.

Table H4-7: Baseline Mean Annual Commercial Impingement Losses at J.R. Whiting Facility and Associated Economic Values

Species	Loss to Commercial Catch from Impingement (lb of fish)	Commercial Value/Fish	Loss in Commercial Value from Impingement
Bullhead spp.	30	$0.33	$10
Channel catfish	46	$0.76	$35
Common carp	29,303	$0.16	$4,688
Freshwater drum	2,070	$0.21	$435
Gizzard shad	807,576	$0.15	$121,136
Sucker spp.	15	$0.09	$1
White bass	2,068	$0.98	$2,027
Total	841,109		$128,333

Tue Feb 05 MST 2002 ; Table C: commercial losses and value for selected species; Plant: jr.whiting.78.79 ; type: I
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Table H4-8: Baseline Mean Annual Commercial Entrainment Losses at J.R. Whiting Facility and Associated Economic Values

Species	Loss to Commercial Catch from Entrainment (lb of fish)	Commercial Value/Fish	Loss in Commercial Value from Entrainment
Channel catfish	2	$0.76	$2
Common carp	17,636	$0.16	$2,822
Freshwater drum	1,581	$0.21	$332
Gizzard shad	48,198	$0.15	$7,230
Sucker spp.	48	$0.09	$4
White bass	1,188	$0.98	$1,165
Total	68,654		$11,554

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Accordingly, EPA estimates that the total baseline economic loss to commercial fisheries ranges from $233,000 to $408,000 for impingement per year, and from $21,000 to $37,000 annually for entrainment at the J.R. Whiting facility (before installation of the impingement deterrent net).

H4-4 Indirect Use: Forage Fish

Many species affected by I&E are not commercially or recreationally fished. For the purposes of this study, EPA refers to these species as forage fish. Forage fish are species that are prey for other species, and are important components of aquatic food webs. Table H4-9 summarizes impingement losses of forage species at J.R. Whiting before net installation and Table H4-10 summarizes entrainment losses. The following sections discuss the economic valuation of these losses using two alternative valuation methods.

Table H4-9: Summary of Mean Annual Impingement of Forage Fish at J.R. Whiting (without impingement deterrent net)

Species	Impingement Count (#)	Age 1 Equivalents (#)	Production Foregone (lb)
Alewife	1,681	1,931	114
Bluntnose minnow	0	0	0
Emerald shiner	637,230	754,130	9,267
Logperch	5,950	7,951	40
Rainbow smelt	2,807	3,776	27
Forage species total	647,668	767,789	9,447

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Table H4-10: Summary of Mean Annual Entrainment of Forage Fish at J.R. Whiting (without impingement deterrent net)

Species	Entrainment Count (#)	Age 1 Equivalents (#)	Production Foregone (lb)
Alewife	0	0	0
Bluntnose minnow	1,623,716	46,669	199
Emerald shiner	7,584,514	69,046	20,775
Logperch	191,471	7,405	570
Rainbow smelt	155,897	20,575	714
Total	9,555,598	143,695	22,257

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Replacement value of fish

The replacement value of fish can be used in several cases. First, if a fish kill of a fishery species is mitigated by stocking of hatchery fish, then losses to the commercial and recreational fisheries would be reduced, but fish replacement costs would still be incurred and should be accounted for. Second, if the fish are not caught in the commercial or recreational fishery, but are important as forage or bait, the replacement value can be used as a lower bound estimate of their value (it is a lower bound because it would not consider how reduction in their stock may affect other species' stocks). Third, where there are not enough data to value losses to the recreational and commercial fisheries, replacement cost can be used as a proxy for lost fishery values. Typically the consumer or producer surplus is greater than fish replacement costs, and replacement costs typically omit problems associated with restocking programs (e.g., limiting genetic diversity).

The cost of replacing forage fish lost to I&E has two main components. The first component is the cost of raising the replacement fish. Table H4-11 displays the replacement costs of forage species at J.R. Whiting. The annual costs of replacing annual forage losses are $18,000 for impingement and $2,500 for entrainment. The per pound costs listed in Table H4-11 are average costs to fish hatcheries across North America to produce different species of fish for stocking (AFS, 1993).

Table H4-11: Replacement Cost of Forage Losses at J.R. Whiting (2000$)			
Species	**Hatchery Costs[a] ($/lb)**	**Annual Cost of Replacing Forage Losses ($2000)**	
		Impingement	**Entrainment**
Alewife	$0.52	$30	$0
Bluntnose minnow	$2.21	$0	$603
Emerald shiner	$0.91	$17,862	$1,635
Logperch	$1.05	$107	$99
Rainbow smelt	$0.34	$25	$136
Total		$18,025	$2,474

[a] These values were inflated to 2000$ from 1989$, but this could be imprecise for current fish rearing and stocking costs.
Source: Sourcebook for Investigation and Valuation of Fish Kill, AFS 1993.
Tue Feb 05 MST 2002 ; Table D: loss in selected forage species; Plant: jr.whiting.78.79 ; type: I Pathname: P:/Intake/Great_Lakes/GL_Science/scodes/jr.whiting/tables.output.78.79/TableD.forage.eco.ter.repl.jr.whiting.78.79.I.csv

The second component of replacement cost is the transportation cost, which includes costs associated with vehicles, personnel, fuel, water, chemicals, containers, and nets. The AFS (1993) estimates these costs at approximately $1.13 per mile, but does not indicate how many fish (or how many pounds of fish) are transported for this price. Lacking relevant data, EPA did not include the transportation costs in this valuation approach.

Production foregone value of forage fish

This approach considers the foregone biomass production of commercial and recreational fishery species resulting from I&E of forage species based on estimates of trophic transfer efficiency, as discussed in Chapter A5 of Part A of this document. The economic valuation of forage losses is based on the dollar value of the foregone fishery yield resulting from the loss of forage.

Summary of values of baseline forage fish losses

Tables H4-12 and H4-13 display the values for baseline losses of forage fish based on the production foregone of fishery yield for I&E, respectively. Baseline losses range from $200 to $400 for impingement and from $40 to $100 for entrainment.

H4-5 Nonuse Values

Recreational consumer surplus and commercial impacts are only part of the total losses that the public realizes from I&E impacts on fisheries. Nonuse or passive use impacts arise when individuals value environmental changes apart from any past, present or anticipated future use of the resource in question. Such passive use values have been categorized in several ways in the economic literature, typically embracing the concepts of existence (stewardship) and bequest (intergenerational equity) motives. Using a “rule of thumb” that nonuse impacts are at least equivalent to 50 percent of the recreational use impact (see Chapter H6 for further discussion), nonuse values for baseline losses at J.R. Whiting are estimated to range from $3,700 to $10,500 for impingement and from $1,700 to $5,800 for entrainment.

Table H4-12: Mean Annual Economic Value of Production Foregone of Selected Fishery Species Resulting from Impingement of Forage Species at J.R. Whiting.

Species	Loss in Production Foregone from Impingement	
	Low	High
Bullhead spp.	$7	$12
Channel catfish	$27	$50
Common carp	$9	$16
Crappie spp.	$9	$43
Freshwater drum	$4	$7
Gizzard shad	$12	$21
Sucker spp.	$0	$1
Sunfish spp.	$21	$69
Walleye	$22	$35
White bass	$55	$147
Yellow perch	$11	$34
Total	$178	$435

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Table H4-13: Mean Annual Value of Production Foregone of Selected Fishery Species Resulting from Entrainment of Forage Species at J.R. Whiting.

Species	Loss in Production Foregone from Entrainment	
	Low	High
Channel catfish	$10	$19
Common carp	$4	$8
Crappie spp.	$1	$4
Freshwater drum	$1	$2
Gizzard shad	$5	$8
Sunfish spp.	$16	$52
White bass	$6	$15
Yellow perch	$0	$1
Total	$43	$109

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H4-6 Summary of Annual Value of Baseline Economic Losses at J.R. Whiting

Table H4-14 summarizes the total economic value of annual baseline I&E at the J.R. Whiting facility. Total impacts range from $244,000 to $458,000 per year from impingement and from $26,000 to $57,000 per year from entrainment. These reflect losses before installation of the deterrent net that reduced impingement significantly (see Chapter H6).

Table H4-14: Summary of Values of Baseline Annual I&E Losses at J.R. Whiting Facility

		Impingement	Entrainment	Total
Commercial: Total surplus (direct use, market)	Low	$233,333	$21,007	$254,340
	High	$408,332	$36,763	$445,095
Recreational (direct use, nonmarket)	Low	$7,316	$3,460	$10,777
	High	$20,929	$11,672	$32,601
Forage (indirect use, nonmarket)				
Production Foregone	Low	$178	$43	$221
	High	$435	$109	$544
Replacement		$18,025	$2,474	$20,499
Nonuse (passive use, nonmarket)	Low	$3,658	$1,730	$5,388
	High	$10,465	$5,836	$16,301
Total (Com + Rec + Forage + Nonuse)[a]	Low	$244,485	$26,241	$270,726
	High	$457,750	$56,745	$514,496

[a] In calculating the total low values, the lower of the two forage valuation methods (production foregone and replacement) was used and to calculate the total high values, the higher of two forage valuation methods was used.
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